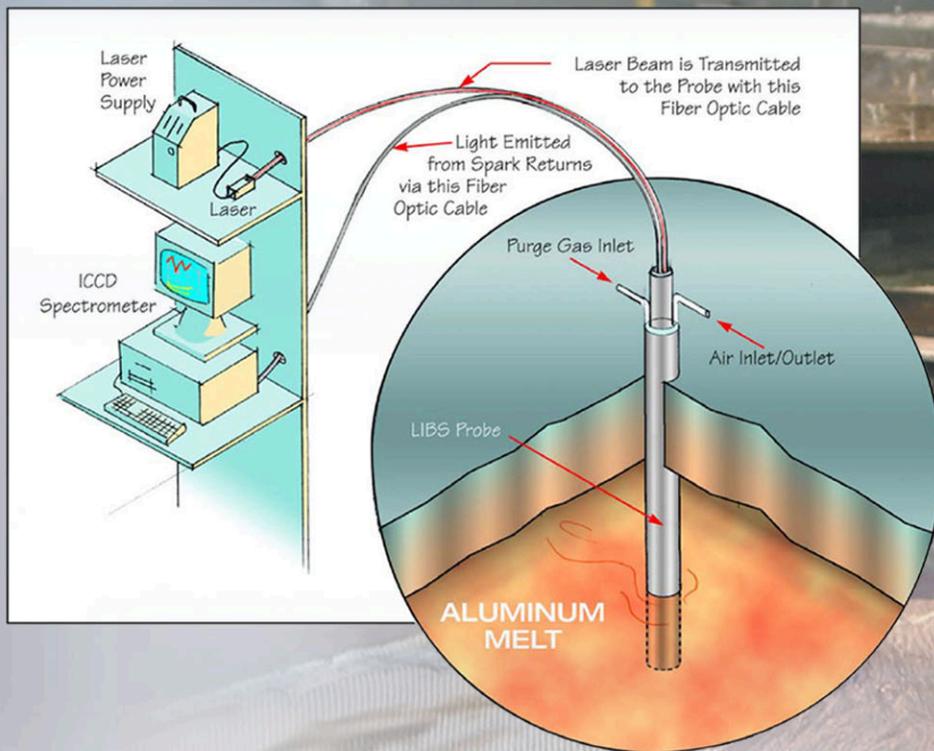


# Sensors & Automation

Fiscal Year 2004 Annual Report



## Industrial Technologies Program

Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance



**U.S. Department of Energy**  
**Energy Efficiency and Renewable Energy**

**ON THE COVER:** The cover features a Laser Induced Breakdown Spectrometer (LIBS) designed to measure in-situ and in real time the concentration of trace elements in melts and feedstocks. The image on the left shows a schematic of the system planned for use in an aluminum melt, while that on the right shows the LIBS system actually at work in a melt at a Commonwealth Aluminum plant, in Ulrichsville, Ohio. The system was devised and developed by Energy Research Company, ERCO, Staten Island, NY. This project was completed in fiscal year 2004.

In operation, a pulsed laser is focused through a fiber-optic cable into a molten aluminum sample, generating high-temperature plasma. As the plasma cools, it radiates light at specific wavelengths corresponding to elemental constituents of the melt. The strengths of the emissions are related to the concentration of each of the elemental constituents. A significant accomplishment has been the development of software for the analysis of the LIBS signal that provides elemental concentrations without the need to calibrate for the elements sought.

Currently, elemental analysis is conducted by periodically grabbing a molten sample and taking it to a lab for analysis. This is expensive and time-consuming, and it does not allow real-time control. By allowing in-situ, real-time measurement of melt constituents, this technology will improve product quality and allow continuous operations, thus saving energy. Energy-savings are projected to be 8.3 trillion Btu annually by 2020. ERCO is also applying the technology to the glass, steel and utility areas.

# Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. EERE's Industrial Technologies Program (ITP) is working to build the Industries of the Future through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices to reduce energy intensity in the industrial sector. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private sector investment.

ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 55 percent of industrial energy consumption.

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Steel

ITP uses a leveraging strategy that maximizes the energy and environmental benefits of its process-specific technology investments by coordinating and cooperating with energy-intensive industries. By working closely with the private sector, ITP is able to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. ITP public-private partnerships also facilitate voluntary efforts, such as the President's Climate VISION initiative, to encourage industry and government to reduce greenhouse gas emissions.

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the ITP partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.



# CONTENTS

- Executive Summary ..... i
- Overview of Industrial Measurement and Control** ..... 1
- Energy Use ..... 1
- The Challenge** ..... 2
- Key R&D Pathways ..... 2
- FY 2004 Highlights & Accomplishments** ..... 5
- R&D Highlights ..... 5
- Partnership Highlights ..... 7
- Improving Energy Efficiency Today ..... 7
- Disseminating Research Results to Industry ..... 8
- Energy Analysis – Targeting Energy Efficiency ..... 8
- Tools, Publications, and Resources Available** ..... 9
- How To Get Involved and Contact Information** ..... 10
- Partnership Information ..... 10
- Access to Resources and Expertise ..... 10
- Where to Go for More Information ..... 11

# EXHIBITS

- 1. Energy Footprint of the U.S. Industrial Sector ..... 1
- 2. Sensors and Automation Targets ..... 2
- 3. R&D Pathways for the Five Sensors & Automation Focus Areas ..... 3
- 4. Key Energy-Saving Opportunities Identified in a Recent S&A Study ..... 4
- 5. Active Sensors & Automation Projects in FY 2004 ..... 5
- 6. Phase II SBIR Projects Managed by S&A in FY 2004 ..... 5
- 7. Examples of Other ITP Projects Relevant to Sensors & Automation ..... 6

# EXECUTIVE SUMMARY

## A Successful Partnership with Industry

Sensors and control systems are integral components of virtually every industrial process. Intelligent control systems and process automation help manufacturers improve plant energy efficiency and boost productivity by increasing throughput, yield and product quality. Other benefits include enhanced worker safety, increased production flexibility and reduced generation of waste products and pollutants.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) leads the federal role in developing advanced energy-efficient and environmentally friendly industrial technologies. Crosscutting R&D in sensors and automation is a component of the overall EERE strategy and contributes to the goals outlined in the National Energy Policy. Advanced sensors and controls can provide data that enable an operator to consistently optimize production processes. Measurement and control systems that permit continuous process operation will aid industry in its push for higher productivity and efficiency. For example, real-time process monitoring and control systems will enable higher quality products from high-speed, precision forming operations, reducing the amount of rejected product that must be reworked.

The EERE Industrial Technologies Program directs the Sensors & Automation (S&A) portfolio, which seeks to increase the energy efficiency of energy-intensive industrial processes by investing in the development of technologies that are applicable in multiple industries. S&A collaborates with other ITP portfolios to create technologies that address some of the most pressing fundamental measurement and control needs facing industry today. This collaboration allows S&A to leverage its resources while helping to develop a core set of enabling technologies for energy-intensive industries. S&A supports projects that address the broad sensor, control and automation priority needs identified in the ITP's industrial portfolios' technology roadmaps.

## A Successful Strategy with Industry

DOE's Office of Energy Efficiency and Renewable Energy leads federal development of advanced energy-efficient and environmentally friendly industrial technologies. Sensors and Automation R&D is a component of the overall EERE strategy, contributing to a reduction in energy intensity of industry, a goal outlined in the National Energy Policy.

EERE/ITP is working to build the Industries of the Future through a strategy that is based on multi-year planning, industry involvement and input during the planning process, and careful analysis and data-based decision making. This strategy not only takes into consideration the interests of the industry as described in their R&D Technology Roadmaps, but also consists of an agenda of analytical studies that provide the basis for decision making. For instance, the *Analysis of Sensors, Controls, Automation, and Robotics Needs in the IOF Technology Roadmaps* published in 2003, has provided the basis for focusing the R&D by identifying industry research interests. The *Assessment Study on Control Systems, Information Processing, Automation, and Robotics in the IOFs* and *Analysis of Crosscutting Potential of ITP Sensor Technologies* were developed using both government and industry data and information, and industry expertise to provide the next level of prioritization for the portfolio. By using these studies, the portfolio is able to design a multi-year R&D plan based on the focus area, barrier, and pathway approach. In this approach, a limited number of critical technology focus areas are identified along with the technical barriers preventing their successful implementation. A multi-year plan (called a "Pathway") is then developed that will guide the R&D activities leading to a successful development of the focus area technology. The "Pathways" are then the basis for solicitations of pre-competitive R&D that addresses both energy efficiency goals outlined in the National Energy Policy and industry research priorities. This successful strategy has now evolved, providing focus on potentially high-impact research to make revolutionary improvements in sensors and automation.

## Achieving Energy Savings: Sensors & Automation Strategy

The Sensors & Automation activity supports a diverse portfolio of cost-shared, crosscutting research addressing technological needs that have broad applicability throughout the industrial sector. S&A leads ITP in providing advanced measurement and control technology solutions to meet the needs of all industry sectors supported by the IOF strategy.

*The goal of ITP's Sensors & Automation portfolio is to identify, develop and deploy integrated measurement systems for operator-independent control of manufacturing processes that can be used by more than one industry and are fully compatible with the harsh industrial environment. Ultimately, systems will enable a level of productivity and quality currently unattainable under human or machine control and produce a 5 percent gain in energy efficiency.*

S&A's research is focused on advanced sensor technologies, next-generation controls and automation, improved information processing, robotics and affordable wireless technologies. The portfolio directly supported 10 projects in FY 2004 and also co-directed other projects in some of the other industrial ITP portfolios. S&A is also responsible for a number of Small Business Innovation Research (SBIR) projects in the sensors and control area. More information about the Sensors & Automation portfolio is available on the ITP Web site at [http://www.eere.energy.gov/sensors\\_automation/portfolio.html](http://www.eere.energy.gov/sensors_automation/portfolio.html).

## **FY 2004 Highlights**

- **In-Situ, Real-Time Measurement of Melt Constituents** – A laser-induced breakdown spectroscopy technology that measures melt constituents in-situ and in real time has been successfully tested at a Commonwealth Aluminum plant. Marketing of this new technology is underway and two commercial sales have already occurred. Additional applications now being investigated with other funding include the glass, steel, and utility (coal-burning power plants) industries.
- **Solid State Sensor for Monitoring Hydrogen** – A solid-state sensor (developed with DOE cost-sharing two years ago) that rapidly detects a wide range of concentrations of hydrogen gas has been modified by project partner Air Products and is now marketed by small business H2scan. The new unit replaces more costly mass spectrometer units; hundreds of units were sold in FY 2004 to a variety of industries.
- **Tunable Diode Laser for Harsh Combustion Environments** – A tunable diode laser sensor for detecting temperature, NO<sub>x</sub> levels and CO levels in harsh furnace environments has been successfully tested at the pilot scale. In FY 2004, the technology was upgraded for use in steel industry electric arc furnace applications, and preliminary field tests have been initiated.
- **Fiber-Optic Sensor for Industrial Process Measurement and Control** – A prototype tunable diode laser absorption spectroscopy instrument for practical use in measuring temperature and chemical composition in combustion applications has been successfully tested with an industrial combustor and an industrial chemical vapor deposition torch. Additional demonstrations are planned for steam methane reforming, a coal-fired power plant application and a boiler simulator.
- **Broadly Tunable Mid-Infrared Hydrocarbon Sensor** – Researchers have developed a broadly tunable, mid-infrared laser spectrometer that can be used in the petrochemical industry for species concentration measurement (particularly propylene, ethylene and methane). Preliminary efforts leading to construction and testing of a prototype portable gas analyzer were completed in FY 2004.
- **Cavity-enhanced Gas Analyzer for Process Control Applications** – An ultra-sensitive, cavity-enhanced absorption cell has been developed as an alternative to gas chromatography for measuring acetylene contamination during ethylene production. Numerous other applications have been identified in industrial process control and environmental monitoring; meanwhile, commercialization efforts are underway.
- **Advanced Wireless Sensors for the Industries of the Future** – The DOE Extreme Measurement Communications Center (EMC<sup>2</sup>) located at Oak Ridge National Laboratory was constructed and made operational. Developers of wireless technologies will be able to use this center to ensure that their technologies have suitable robustness, latency, throughput and security for deployment in the industrial sector.

- **Support for the Creation of WINA** – S&A assisted suppliers and end-users of industrial wireless technology with the creation of WINA, the Wireless Industrial Networking Alliance. WINA’s major objective is to promote the adoption of wireless networking technologies and practices that will help increase industrial productivity and efficiency. In February 2004, S&A assisted in facilitating the first WINA General Assembly. In June 2004, more than 450 people signed up to attend a WINA seminar held during the Sensors Expo in Detroit.

# OVERVIEW OF INDUSTRIAL MEASUREMENT AND CONTROL

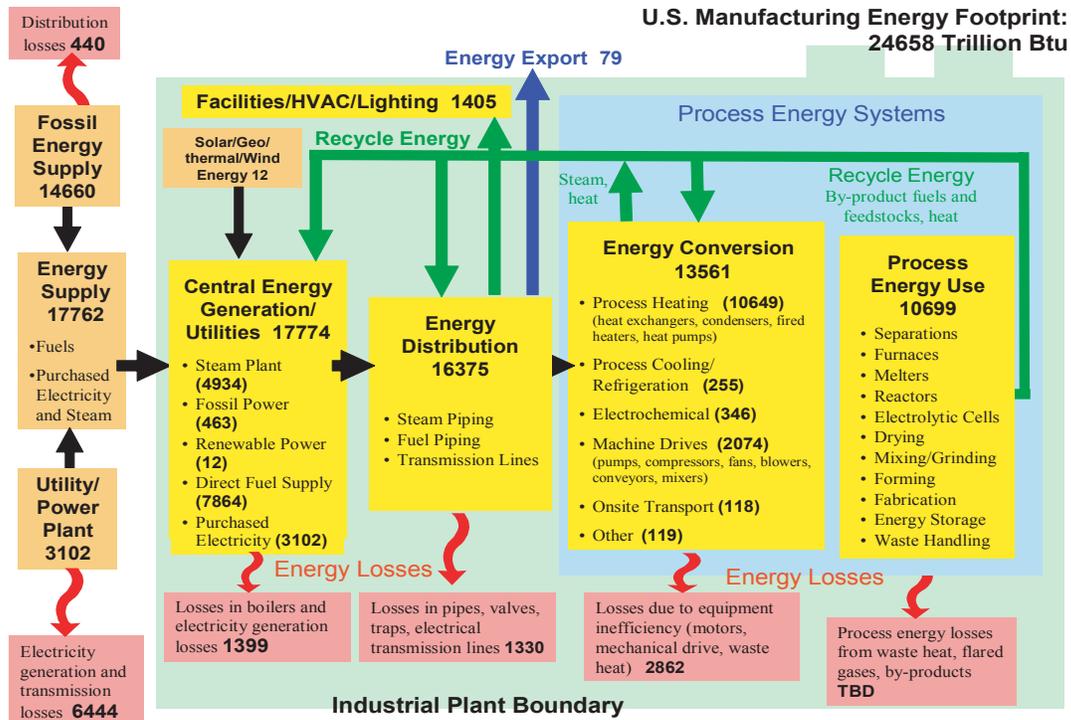
Measurement and control systems are integral components of virtually every industrial process and are essential to the proper operation and profitability of most industries. Intelligent control systems and process automation help manufacturers improve plant energy efficiency and boost productivity by increasing throughput, yield and product quality. These technologies also increase the flexibility of production processes while reducing their impact on the environment and enhancing worker safety.

The United States is both the largest provider of and the largest single national market for measurement and control products and services. Approximately 1,000 manufacturers and distributors of sensor and control equipment currently exist in this country. Total employment of these companies exceeds 50,000, with a payroll of more than \$2 billion per year. The market for process controls is valued annually at approximately \$26 billion worldwide; the total value of U.S. shipments was \$9 billion in 2002, with process industries accounting for about 70 percent (more than \$6 billion).

## Energy Use

Industrial energy end-use patterns can be illustrated through the use of an energy footprint. The footprint shown in Exhibit 1 demonstrates that energy delivered is lost prior to being used in specific processes. Close to 3,000 trillion Btus (3 quads) of energy are lost in energy conversion processes (e.g., process heating equipment, motors) and an unknown additional amount is lost in manufacturing processes. These are the areas in which Sensors & Automation can help industry make meaningful gains in energy efficiency.

**Exhibit 1  
Energy Footprint of the U.S. Industrial Sector**



# THE CHALLENGE

The entire manufacturing industry needs intelligent control systems to improve their resource efficiency and product quality and to minimize generation of waste and pollutants. The economic impact of measurement and control technology products reaches beyond the industry sectors where these products are applied.

S&A leads ITP in providing advanced measurement and control technology solutions to meet the needs of all industry sectors supported by the ITP portfolio strategy. The goal of the Sensors & Automation portfolio is to identify, develop and deploy integrated measurement systems for operator-independent control of manufacturing processes that can be used by more than one industry and are fully compatible with the harsh industrial environment. Ultimately, systems will enable a level of productivity and quality currently unattainable under human or machine control and produce a gain of 5 percent in energy efficiency.

Many challenges exist in developing advanced measurement and intelligent control systems that meet end-user manufacturers' needs. These challenges relate to performance characteristics of the technologies, as well as their adoption by industry.

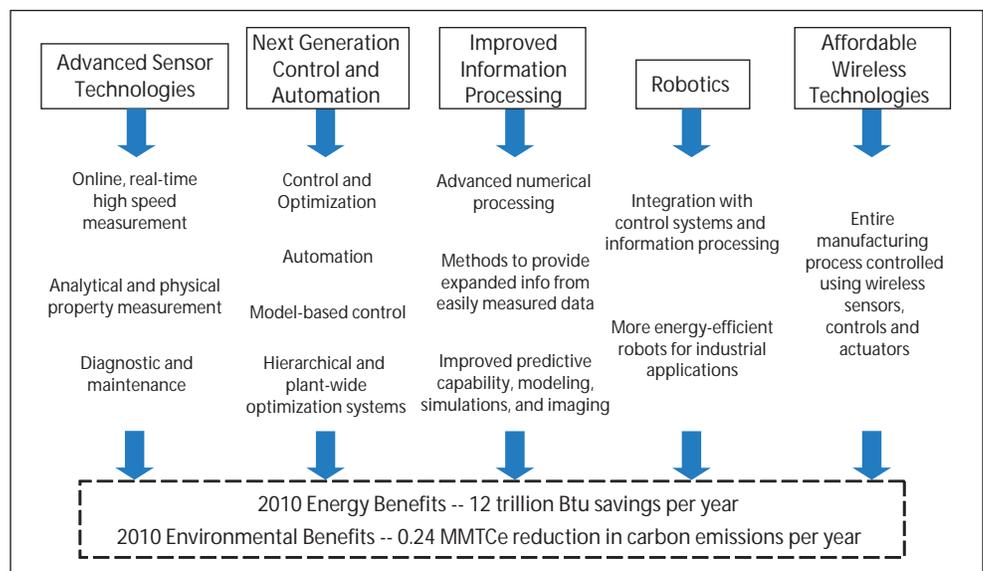
- proven operational reliability and sustained performance in harsh environments
- robustness and general utility
- real-time capability and the need for faster and more discriminating sensors to take advantage of today's processing power
- value to the customer and payback period
- physical size
- invulnerability to interference and security (for wireless technologies)
- awareness of the value of sensor data, particularly in preventing unplanned maintenance
- awareness that sensors can give greater capabilities to older equipment, thereby decreasing maintenance costs

## Key R&D Pathways

Sensors & Automation directly sponsors the development of integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors. S&A also collaborates with the industrial ITP portfolios to co-fund sensors and controls research for these industries.

The roadmaps of the seven Industries of the Future identify improved sensors and controls as one of the highest priority industry needs for increasing manufacturing energy efficiency. The projects supported by S&A address the broad sensor, control and automation priority needs identified in the ITP industrial technology roadmaps. Over the last several years, an increased emphasis has been placed on projects to develop sensor, controls and automation technologies capable of revolutionizing the

**Exhibit 2  
Sensors & Automation Targets**



manufacturing processes used by the IOFs, thereby saving even more energy.

The S&A research portfolio can be organized into five focus areas: advanced sensor technologies, next-generation control and automation technologies, improved information processing, robotics, and affordable wireless technologies. Exhibit 2 presents major opportunities or targets for each of these focus areas. Exhibit 3 shows the R&D pathways that ITP has identified for achieving the targets. Available resources currently limit active S&A involvement in all focus areas.

### Exhibit 3 R&D Pathways for the Five Sensors and Automation Focus Areas

<u>S&amp;A Focus Area</u>	<u>R&amp;D Pathways</u>
Advanced Sensor Technologies	 Make sensors compatible with the harsh industrial environment Increase sensor capabilities; make them real-time, on-line, non-intrusive Development, lab testing, host site evaluation
Next-Generation Control and Automation	 Develop model-based control and predictive control Develop hierarchical and plant-wide optimization systems Automate the sense-infer-act loop to achieve operator-independent plant optimization
Improved Information Processing	 Develop means for data acquisition, transformation into useful information, and use the information for improved process design, operation, energy minimization, and quality control
Robotics	 Integrate/incorporate sensors, information processing, and control systems into robotic systems Redesign production line with robots to solve long-standing production problems Redesign robots to increase efficiency
Affordable Wireless Technologies	 Evaluate candidate industrial wireless sensor systems in test facility Select best technologies for in-plant testing Measure performance of motors using wireless systems Investigate power harvesting techniques

The “Affordable Wireless Technologies” focus area is relatively new and has received increased emphasis in the past two years. Wireless sensor systems hold the potential to help U.S. industry use energy and materials more efficiently, lower production costs and increase productivity. During FY 2003, DOE published the vision document *Industrial Wireless Technology for the 21<sup>st</sup> Century*. In line with this vision, the goal of DOE’s industrial wireless initiative is to develop a non-proprietary, open architecture wireless network and evaluate the network in an industrial production facility. This network will replace the wires now used in sensor and control systems and will allow operational approaches that are not practical at this time, such as ubiquitous sensing. The target markets of this technology include the ITP industrial portfolios, as well as other manufacturing industries. Three new wireless technology projects were begun in FY 2004 and several projects to develop power sources for wireless systems were selected as part of an SBIR initiative. S&A’s wireless R&D activities were recognized in the April 26<sup>th</sup>, 2004 issue of *Business Week*.

Projects in S&A’s portfolio typically run three to five years and are cost-shared by the technology developer (private research companies, technology suppliers and universities). A steering committee comprised of representatives from the IOFs and other experts provides direction and guidance. In FY 2004, S&A had 10 active projects and managed seven SBIR projects.

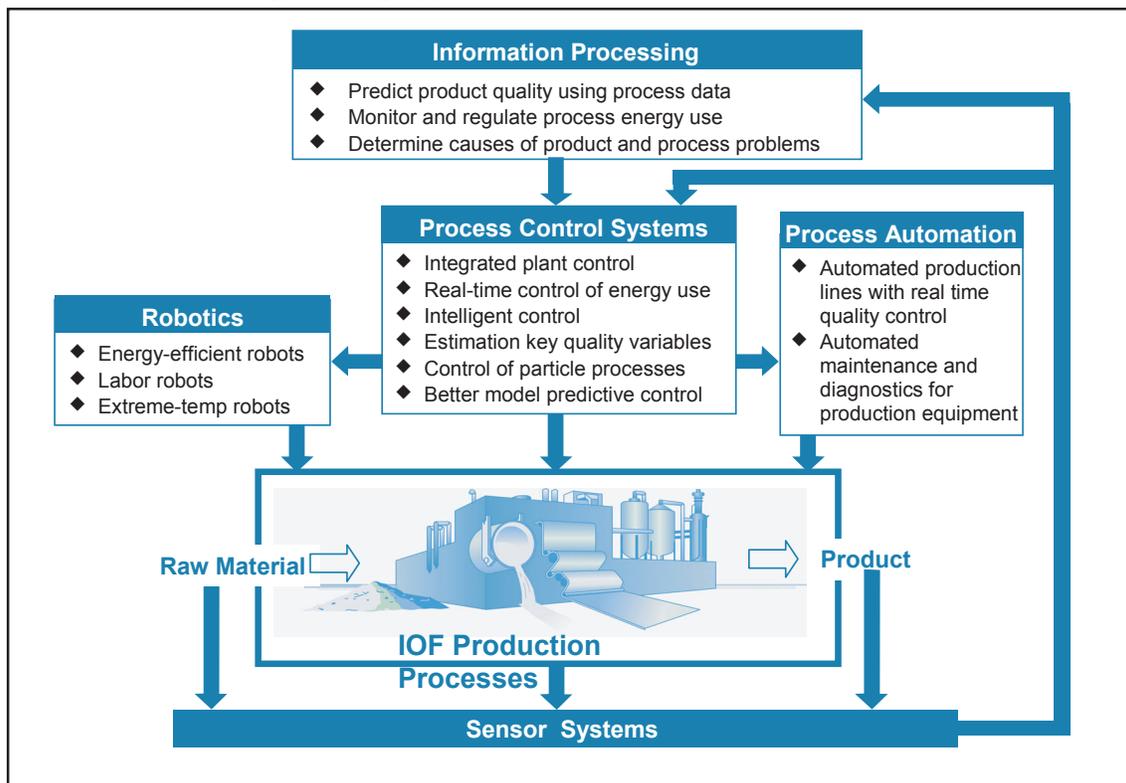
In addition to supporting new concepts (such as wireless technology) for next-generation sensors and automation, S&A works with the various ITP industrial portfolios to improve existing systems, both industry-specific and cross-cutting. This strategy ensures that the portfolio will help meet the measurement and control needs of the ITP portfolios without neglecting the development of fundamentally new concepts that could revolutionize how measurement and control functions are performed throughout the industrial sector. In line with this new strategy, S&A awarded a total of \$16 million over five years to five new crosscutting sensors and controls research projects in FY 2004. With the required minimum 50 percent non-federal cost-share, the total value of projects undertaken could reach \$33 million.

In March 2004, Sensors & Automation participated in an ITP-wide peer review to solicit comments from stakeholders on the focus and direction of the program’s activities. The feedback received on the S&A portfolio was generally positive, with particular note of their breadth and cross-cutting nature. It was noted that this portfolio has produced a relatively large number of commercial successes since its inception during FY 1999.

To ensure broad participation, S&A's solicitations are announced in trade society publications, Web sites, and meetings, the *Commerce Business Daily*, *FedBizOpps* and the Sensors & Automation Web site. Selection of projects follows merit-based criteria that emphasize projected energy, environmental and economic benefits based on sound analysis using a standardized procedure available in the online Project Evaluation Tool (<http://www.energetics.com/sensorstool>). This rigorous solicitation development and implementation process ensures targeted, competitive solicitations for pre-competitive R&D.

In FY 2004, S&A completed a broad analysis of the current state of the art in controls, automation, robotics and information processing (the sensors area was the focus of a similar study conducted in FY 2002) to further refine its strategy and identify the best industrial research opportunities for S&A in these four areas. The overall effort was comprised of expert study teams working independently in each of the four areas, coordinated by Dr. Frank Doyle of the University of California at Santa Barbara. The opportunities identified in the study are shown in Exhibit 4.

**Exhibit 4**  
**Key Energy-Saving Opportunities Identified in a Recent S&A Study**



# FY 2004 HIGHLIGHTS AND ACCOMPLISHMENTS

Sensors & Automation supports a diverse portfolio of cost-shared research that addresses high-risk, high-impact needs that have a broad application throughout multiple industries. In FY 2004, S&A's portfolio included 10 active projects, one of which was completed that year (see Exhibit 5, which also indicates the prime contractor performing the research and the relevant IOFs). S&A also directed three Phase II Small Business Innovation Research (SBIR) grant projects (Exhibit 6). In addition, over 40 projects in the areas of sensors and controls that are funded by other ITP IOFs are shown in Exhibit 7.

Fact sheets describing projects in the Sensors & Automation portfolio are located on the DOE/ITP Web site at [http://www.eere.energy.gov/industry/sensors\\_automation](http://www.eere.energy.gov/industry/sensors_automation).

Sensors & Automation achieved a number of noteworthy accomplishments in FY 2004 (described below).

## R&D Highlights

**In-Situ, Real-Time Measurement of Melt Constituents** – Energy Research Company has developed a laser-induced breakdown spectroscopy technology that measures melt constituents in-situ and in real time. The technology, which was developed for use in the recycled aluminum industry, accurately measures the melt composition at any point in the melt. A full-scale commercial installation at a Commonwealth Aluminum facility has been completed and Energy Research is continuing its commercialization efforts. Solios Thermal has been granted a license to market the system worldwide to the aluminum industry and two commercial sales have already been made. Energy Research is also looking at applications in the glass, steel and utility industries.

**Solid State Sensor for Monitoring Hydrogen** – A solid state sensor for measuring hydrogen content of gaseous streams was developed by Penn State using Sandia National Laboratories' technology with DOE co-funding in FY 2003. The sensor was then further improved by Air Products and is now sold by small business H2scan. Users report that the performance of the \$3,500 unit is equivalent to that of the \$150,000 mass spectrometer system now used. Hundreds of units are now being used to measure the hydrogen content of gas streams over the 0.5 to 99 percent range under the demanding conditions of hydrogen production and use, as well as to detect hydrogen leaks.

**Tunable Diode Laser for Harsh Combustion Environments** – American Air Liquide has developed a tunable diode laser sensor for monitoring key

## Exhibit 5 Active Sensors & Automation Projects in FY 2004

- In-Situ, Real-Time Measurement of Melt Constituents in the Aluminum, Glass, and Steel Industries; Prime: Energy Research Company ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/libs.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/libs.pdf))
- Diagnosis and Control of Natural Gas-Fired Furnaces via Flame Image Analysis\*; Prime: University of Missouri at Rolla ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/flame.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/flame.pdf))
- Remote Automatic Material Online Sensor (Forest Products); Prime: Quantum Magnetics ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/online.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/online.pdf))
- Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments; Prime: American Air Liquide ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/aal.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/aal.pdf))
- Advanced Wireless Sensors for the Industries of the Future (Steel, Aluminum, Mining, Glass, Chemicals, Forest Products, Metal Casting, Petroleum Refining); Prime: ORNL ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/ornl.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/ornl.pdf))
- Eaton Wireless Sensor Network for Advanced Energy Management Solutions (Steel, Aluminum, Mining, Glass, Chemicals, Forest Products, Metal Casting, Petroleum Refining); Prime: Eaton ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/eaton\\_wireless.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/eaton_wireless.pdf))
- Distributed Wireless Multisensor Technologies - A Novel Approach to Reducing Motor Energy Usage (Steel, Aluminum, Mining, Glass, Chemicals, Forest Products, Metal Casting, Petroleum Refining); Prime: General Electric Global Research ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/dist\\_wireless.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/dist_wireless.pdf))
- Wireless and Sensing Solutions Advancing Industrial Efficiency (Steel, Aluminum, Chemicals, Petroleum Refining); Prime: Honeywell International ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/honeywell\\_wireless.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/honeywell_wireless.pdf))
- SQA: Surface Quality Assured Steel Bar Program (Steel); Prime: OG Technologies ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/sqa\\_surface.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/sqa_surface.pdf))

\* Project was successfully completed in FY 2004

## Exhibit 6 Phase II SBIR Projects Managed by S&A in FY 2004

- Fiber-Optic Sensor for Industrial Process Measurement and Control (Chemicals, Combustion Applications) ([http://www.eere.energy.gov/industry/sensors\\_automation/pdfs/fiber\\_optic.pdf](http://www.eere.energy.gov/industry/sensors_automation/pdfs/fiber_optic.pdf))
- Cavity-enhanced Gas Analyzer for Process Control Applications (Chemicals, Petroleum Refining)
- Broadly Tunable Mid-Infrared Hydrocarbon Sensor (Chemicals) (fact sheet)

## Exhibit 7

### Examples of Other ITP Projects Relevant to Sensors & Automation

<p><b>Aluminum Projects</b></p> <ul style="list-style-type: none"> <li>● Intelligent Potroom Operation</li> <li>● Automotive Aluminum Scrap Sorting</li> </ul> <p><b>Chemicals Projects</b></p> <ul style="list-style-type: none"> <li>● Development of In-Situ Analysis for the Chemical Industry</li> </ul> <p><b>Forest Products Projects</b></p> <ul style="list-style-type: none"> <li>● Wireless Microwave Wood Moisture Measurement System for Wood Drying Kilns</li> <li>● Guided Acoustic Wave Monitoring of Corrosion and Erosion in Recovery Boiler Tubing</li> <li>● Online Fluidics Controlled Headbox</li> <li>● Contact-less Real-Time Monitoring of Paper Mechanical Properties</li> <li>● Implementation of an Advanced Quality Control System at a Newsprint Manufacturing Plant</li> <li>● Development of Prototype Electrokinetic Sonic Amplitude System for Measurement of Zeta Potential</li> </ul> <p><b>Glass Projects</b></p> <ul style="list-style-type: none"> <li>● Measurement and Control of Glass Feedstocks</li> <li>● Monitoring and Control of Alkali Volatilization and Batch Carryover</li> </ul>	<p><b>Metal Casting Projects</b></p> <ul style="list-style-type: none"> <li>● In-Situ Real-Time Monitoring and Control of Mold Making and Filling Processes</li> </ul> <p><b>Mining Projects</b></p> <ul style="list-style-type: none"> <li>● Horizon Sensing</li> <li>● Automated Machine Fluid Analysis System</li> <li>● High-Temperature Superconductors in Underground Communications</li> <li>● Imaging Ahead of Mining</li> <li>● Real-Time Coal/Ore Grade Sensor</li> <li>● Wireless Mine-Wide Telecommunications</li> <li>● Development of New Geophysical Techniques/Mineral Explorations and Mineral Discriminator</li> <li>● Investigating GPS/IMU Positioning System for Mining Equipment</li> <li>● Demonstration of Crosswell Imaging Technology and Advanced Drillstring Radar Navigation for Horizontal Directional Drilling</li> <li>● Effective Conveyor Belt Inspection for Improving Mining Productivity</li> <li>● Robot-Human Control Interactions in Mining Operations</li> <li>● Online SAG Mill Grinding Pulse Measurement and Optimization</li> </ul> <p><b>Steel Projects</b></p> <ul style="list-style-type: none"> <li>● Automated Steel Cleanliness Analysis Tool</li> <li>● Controlled Thermomechanical Processing of Tubes and Pipes</li> </ul>
---	--

combustion species (CO, O<sub>2</sub> and H<sub>2</sub>O) and gas temperature in industrial furnaces. The non-intrusive nature of the technology is ideally suited for harsh, high-temperature environments with corrosive gases and/or high levels of particulate matter. The data from the new sensor will help furnace operators optimize their combustion processes, thereby increasing efficiency and reducing emissions of criteria pollutants and CO<sub>2</sub>. The technology has already been demonstrated in a steel reheat furnace and an aluminum reverberatory furnace and is currently being upgraded for use in electric arc steelmaking furnaces.

**Advanced Wireless Sensors for the Industries of the Future** – Oak Ridge National Laboratory (ORNL) is facilitating the deployment of wireless technologies to industry by demonstrating that the critical issues (e.g., reliability, security, robustness) are being addressed by the developers. In FY 2004, ORNL commissioned the DOE Extreme Measurement Communications Center (EMC<sup>2</sup>) to characterize and simulate the performance of candidate industrial wireless telemetry devices in harsh industrial environments.

**Wireless Sensor Network for Advanced Energy Management Solutions** – Eaton Corporation has initiated an effort to research, develop, test and deploy a self-configuring wireless sensor network that operates within a range of open wireless protocols and integrates with advanced energy management software. The first phase of this project will include development of a baseline system to demonstrate the feasibility of the networking concepts. The goal is to use wireless technology to enable electrical distribution and power control systems within a plant to communicate and report diagnostic information.

**Distributed Wireless Multisensor Technologies** – In this new FY 2004 project, General Electric Global Research and its partners seek to bring the benefits of continuous monitoring to smaller (less than 1,000 hp) motors through the development of low-cost, distributed wireless sensors. Continuous monitoring should allow industries to better maintain and improve the efficiency of their electric motors. Initial technical efforts are focusing on characterization of the manufacturing RF environment and identifying and adapting wireless technology.

**Wireless and Sensing Solutions Advancing Industrial Efficiency** – This new project, led by Honeywell International, consists of two separate efforts: the development of a wireless network for secure industrial applications and the development of innovative technology for sampling and composition analysis of gaseous and liquid process streams. Upcoming activities include demonstration of the security and reliability of multiple independent wireless components and the development and lab testing of a gaseous stream analyzer that is sufficiently rugged for industrial applications.

**SQA™: Surface Quality Assured Steel Bar Program** – OG Technologies has initiated research that seeks to alleviate surface quality problems in special quality steel bars and rods. The new Surface Quality Assurance program will automatically and accurately mark residual surface defects for downstream removal using OG's HotEye™ technology to deliver high-definition images of workpieces at or exceeding 1,450°C. Research is currently focused on improving the accuracy of the in-line surface detection system.

**Fiber-Optic Sensor for Industrial Process Measurement and Control** – In Phase II of an SBIR project, MetroLaser, Inc. has developed a new commercial temperature and chemical sensor primarily for high-temperature gas combustion measurement and process control applications. The system uses tunable diode laser absorption spectroscopy, making it less intrusive and more accurate and flexible than currently used extractive sampling techniques. MetroLaser has successfully demonstrated temperature measurement in the hot gases and flames of industrial combustors. Additional tests will be conducted in three applications – steam methane reforming, a coal-fired power plant and a boiler simulator – and MetroLaser has signed a North American distributorship agreement with Bergmans Mechatronics, LLC to market this technology.

**Broadly Tunable Mid-IR Hydrocarbon Sensor** – This SBIR Phase II project is developing a broadly tunable mid-infrared laser spectrometer that can be used to make rapid, onsite measurements of industrial gases in the petrochemical and other industries. Physical Sciences Inc., together with Dow Chemical and Analytical Specialties, Inc., is developing this system as an alternative to gas chromatography, which does not allow real-time process control. Activities in FY 2004 focused on fabricating key components of the system, including the laser source and preparing for the fabrication of a portable prototype analyzer.

**Cavity-enhanced Gas Analyzer for Process Control Applications** – Los Gatos Research is developing an alternative to gas chromatography for measuring acetylene contamination during ethylene production in this Phase II SBIR project. The heart of the new analyzer is an ultra-sensitive, cavity-enhanced absorption cell that will permit petrochemical manufacturers to incorporate real-time control, saving millions of dollars per year. Dow Chemical Company has been providing both laboratory and field testing of the analyzer and has validated its sensitivity, time response, and longevity. Additional applications in measuring emissions from engines, oil drilling, and semiconductor manufacturing are being considered, as are potential opportunities in military and medical markets. The first commercial units of the new technology are expected to be sold by the end of 2004.

## **Partnership Highlights**

**Wireless Industrial Networking Alliance** – Sensors & Automation is assisting suppliers and end-users of industrial wireless technology with the creation of WINA, the Wireless Industrial Networking Alliance. This alliance emerged from DOE-sponsored wireless technology activities in FY 2003, including the publication of *Industrial Wireless Technology for the 21<sup>st</sup> Century*, a unified vision for the future of this rapidly evolving technology. WINA's major objective is to promote the adoption of wireless networking technologies and practices that will help increase industrial productivity and efficiency. In February 2004, S&A assisted WINA in conducting the first WINA General Assembly held in Research Triangle Park, North Carolina, attended by more than 60 end-users, suppliers, and system integrators. S&A also provided support to heavily attended WINA seminars held in conjunction with Sensors Expo 2004 and ISA Expo 2004.

**International Forum on Process Analytical Chemistry** – The annual International Forum on Process Analytical Chemistry (IFPAC) is considered the foremost conference in process analysis and technology. IFPAC-2004, held in January in Arlington, Virginia, included an entire session devoted to presentations on ITP-sponsored research in sensors and controls. The Forum was attended by hundreds of representatives from the chemical and pharmaceutical industries, as well as the commercial vendor community.

## **Improving Energy Efficiency Today**

**Technology Delivery Program** – Sensors & Automation focuses on mid- to long-term technology research. EERE/ITP's Technology Delivery Program offers other products and services to assist industry in saving energy in the near-term. These products and services include software tools and associated training to improve the efficiency of plant utility systems, cost-shared plant assessments, no-cost plant audits for small and mid-size

companies and numerous helpful publications describing applications of good plant operating practices. Activities such as these have the potential to save U.S. industry millions of dollars annually. To learn more, please visit <http://www.oit.doe.gov/bestpractices>. For more information on the no-cost audits, please visit <http://www.oit.doe.gov/iac>.

## **Disseminating Research Results to Industry**

**Sensors & Automation Website** – The Sensors & Automation Web site is a valuable tool for disseminating information on the portfolio's activities. The Web site highlights R&D projects, provides access to EERE publications and notes upcoming solicitations. The Web site also contains a "News" section that provides articles on recent events, updates on research successes and notifications of new software tools and other services of relevant interest to manufacturers and users of sensor and control systems technology. It also includes contractor presentations from the most recent annual portfolio review meetings. The S&A Web site was updated in FY 2004 as part of an ITP-wide redesign project.

## **Energy Analysis – Targeting Energy Efficiency**

**Sensors & Automation Project Evaluation Tool** – An interactive software tool was created to help applicants to Sensors & Automation solicitations analyze the potential energy and environmental benefits of their technologies. This online tool allows for standardized analysis of the proposed projects, which facilitates selection of the best technologies for funding. Applicants to S&A solicitations are now required to use the tool.

**GPRA Analysis** – This annual exercise was completed for projects considered in the FY 2006 budget. The GPRA analysis estimates future benefits of emerging technologies in the Sensors & Automation portfolio based on market penetrations, energy savings and environmental emission reductions.

**Assessment Study on Sensors & Automation in the Industries of the Future** – Teams of experts in the areas of controls, automation, robotics and information processing have conducted broad analyses of the state of the art in these four areas, which are of great interest to S&A. The results of the study, which was completed in FY 2004, includes lists of the top energy-saving R&D opportunities in each area, the industrial sectors with the greatest needs and estimates of the potential energy savings that could be achieved. The study will help guide S&A in soliciting proposals for funding projects that could have the greatest impact on reducing industrial energy consumption.

## TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

EERE offers valuable tools and publications to help companies improve productivity and energy efficiency. Some of these resources are described below. View the Web site at [http://www.eere.energy.gov/industry/sensors\\_automation](http://www.eere.energy.gov/industry/sensors_automation) for a complete listing.

**Fact Sheets** – Publications describing R&D projects, emerging technologies and commercial successes are available on the Web site.

**Industrial Wireless Technology for the 21<sup>st</sup> Century** – Over 30 individuals representing the extended industrial wireless community have cooperatively developed a unified vision for the future of this rapidly evolving technology. The vision document defines specific goals and challenges, provides some context for non-experts and maps out the key hurdles to fully take advantage of wireless capabilities in industrial environments.

**Project Evaluation Tool** – Software is available at [http://www.energetics.com/sensor\\_tool](http://www.energetics.com/sensor_tool) that can be used to estimate the potential energy and environmental benefits of a proposed new measurement or control technology.

**Corporate Brochure** – The EERE/ITP corporate brochure, *Results for Today, Leadership for Tomorrow*, provides an overview of ITP and the collaborations, partnerships, tools, resources and opportunities available to the nation's essential, energy-intensive industries. The brochure and similar overview publications can be found at <http://www.eere.energy.gov/about/brochures.html>.

# HOW TO GET INVOLVED AND CONTACT INFORMATION

## Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at <http://www.eere.energy.gov/industry>.

- Collaborative, cost-shared research and development projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.
- Industries of the Future Partnerships increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.
- Allied Partnerships provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.
- State energy organizations work with ITP in applying technology to assist their local industries. ITP assists states in developing partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.
- EERE's technical programs (of which ITP is one of 11) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at <http://www.eere.energy.gov>.
- The President's Climate VISION (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See <http://www.climatevision.gov> for details.

## Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at <http://www.eere.energy.gov/industry> or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers energy management best practices to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.
- Our suite of powerful system optimization software tools can help plants identify and analyze energy-saving opportunities in a variety of systems.
- Training sessions are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.
- ITP's qualified industrial energy specialists will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of publications gives companies the resources they need to achieve immediate energy savings.
- Plant-wide energy assessments are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.
- The DOE Regional Offices provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in the Southeast, Northeast, Midwest, Central, Mid-Atlantic, and Western regions. Visit <http://www.eere.energy.gov/rso.html> for more information.

## **Where to Go For More Information**

Visit our Web site: [http://www.eere.energy.gov/industry/sensors\\_automation/](http://www.eere.energy.gov/industry/sensors_automation/)

Learn about all EERE programs: <http://www.eere.energy.gov>

**EERE Information Center** answers questions on EERE's products, services and 11 technology programs, refers callers to the most appropriate EERE resources, and refers qualified callers to the appropriate expert networks. You may contact the EERE Information Center by calling 1-877-EERE-INF (1-877-337-3463) or by completing the form at this site: <http://www.eere.energy.gov/informationcenter>. A customer service specialist or energy expert at the EERE Information Center will respond to your inquiry.

For print copies of DOE, EERE and ITP Publications, contact the  
Energy Efficiency and Renewable Energy Information Center  
P.O. Box 43165  
Olympia, WA 98504-3165  
<http://www.eere.energy.gov/informationcenter/>

### **For questions regarding Sensors & Automation portfolio activities, please contact:**

Gideon Varga  
Industrial Technologies Program  
Office of Energy Efficiency and Renewable Energy  
EE-2F  
U.S. Department of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585-0121  
Phone: 202-586-0082  
Fax: 202-586-7114  
Email: [Gideon.Varga@ee.doe.gov](mailto:Gideon.Varga@ee.doe.gov)

## **A Strong Energy Portfolio for a Strong America**

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

### **The Opportunities**

#### *Biomass Program*

Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

#### *Building Technologies Program*

Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

#### *Distributed Energy & Electric Reliability Program*

A more reliable energy infrastructure and reduced need for new power plants

#### *Federal Energy Management Program*

Leading by example, saving energy and taxpayer dollars in federal facilities

#### *FreedomCAR & Vehicle Technologies Program*

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

#### *Geothermal Technologies Program*

Tapping the Earth's energy to meet our heat and power needs

#### *Hydrogen, Fuel Cells & Infrastructure Technologies Program*

Paving the way toward a hydrogen economy and net-zero carbon energy future

#### *Industrial Technologies Program*

Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

#### *Solar Energy Technology Program*

Utilizing the sun's natural energy to generate electricity and provide water and space heating

#### *Weatherization & Intergovernmental Program*

Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

#### *Wind & Hydropower Technologies Program*

Harnessing America's abundant natural resources for clean power generation

To learn more, visit [www.eere.energy.gov](http://www.eere.energy.gov)

### **Sensors & Automation**

#### ***Industrial Technologies Program***

**Boosting the productivity and competitiveness of U.S. industry**



**U.S. Department of Energy**  
**Energy Efficiency and Renewable Energy**

*published February 2005*